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METHODS OF MEASUREMENT ON DIRECT READING *p*H METERS

(*First Revision*)

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METHODS OF MEASUREMENT ON DIRECT READING *p*H METERS

(First Revision)

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Indian Standard
METHODS OF MEASUREMENT ON DIRECT READING *p*H METERS
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 21 November 1979, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was originally issued in 1967. The present revision has been undertaken to incorporate the current practice in the methods of test.

0.3 This standard prescribes the conditions and detailed procedures for the tests to be conducted on *p*H meters to determine their performance characteristics.

0.3.1 The tests prescribed in this standard apply only to complete instruments; separate consideration for the component parts has not been given in this standard.

0.4 This standard lays down a single method of measurement for each characteristic so as to achieve the required degree of precision. It is, however, not intended to exclude other alternative methods of measurement for which necessary measuring equipment may be available and which are of equal or greater precision than the method prescribed in this standard.

0.5 This standard shall be read in conjunction with IS : 2711-1966* which has concentrated on the essential aspects of the electrical performance requirements of *p*H meters. Compliance tests have been designed with typical glass and reference electrode usage in mind, but in order to make the tests independent of electrode performance, these compliance tests are conducted by injecting dc potential differences from a potentiometer.

*Specification for direct reading *p*H meters (*second revision*).

0.6 Principal cost-restricted limitations of *p*H meters are deflection meter scaling, input current, and linearity of, and dial scaling on, temperature compensator potentiometers. Possible inaccuracies arising from the features can be minimized by attention to the way the *p*H measurements are carried out. Errors due to input current can be considerable for very high electrical resistance glass electrodes or for electrodes with resistances in the normal range (100 MΩ to 350 MΩ) at room temperatures but used at low temperatures. Errors arising from input current are of similar origin to those described as 'grid current' errors when valve electrometer tubes were employed in *p*H meters up to a decade ago. Unlike grid current errors, however, the input current error may be of either sign, since present day solid-state input stages may cause to flow in either direction through the glass electrode — reference electrode pair. Further more the current drawn depends on the voltage applied to the input stage.

0.7 It is true that the conversion of the measured potential to the indicated *p*H carried out by the temperature compensator of a *p*H meter is an incomplete one even if isopotential control is used. While the compensator operates according to the slope factor, corrections for smaller effects of a physio-chemical origin are not made. Moreover, the quality of the components available and inadequacies in the scaling of the slope factor adjustment dial frequently limit the accuracy of the *p*H measurement. If the dial cannot be set accurately and reproducibly to a particular temperature (for example, 27°C) then there may even be inaccuracy in the measurement of *p*H values when both sample and standard buffer are temperature controlled to within ± 0·1°C.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard prescribes the conditions and the detailed procedures for the measurement of performance characteristics of direct reading *p*H meters covered by IS : 2711-1966†.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given below in addition to those given in IS : 2711-1966† shall apply.

*Rules for rounding off numerical values (*revised*).

†Specification for direct reading *p*H meters (*second revision*).

2.2 Temperature Compensation Control — The control provided on the instrument for temperature compensation. This compensation is for the initial setting of the control to the temperature of the liquid under measurement, but does not compensate for any changes in temperature while under measurement.

2.3 Sensitivity — The least count in *p*H fed to the input of the *p*H meter which will give a readable variation on the indicator.

2.4 Reproducibility — The limits of variation on the indicator when all other factors are kept constant and a constant input is fed to the instrument at regular intervals.

3. GENERAL CONDITIONS OF MEASUREMENT

3.0 Unless otherwise specified, measurements shall be made under normal measuring conditions as specified in **3.1 to 3.5.**

3.1 Normal Supply Voltage — Rated voltage shall be applied to the *p*H meter.

3.1.1 In case of ac mains operation, the voltage shall be applied at the rated frequency.

3.1.2 The harmonic content of ac mains supply voltage shall not exceed 5 percent.

3.1.3 The voltage applied to the *p*H meter shall be held constant within ± 2 percent of the rated value during the measurement.

3.1.4 In case of battery operation, batteries of the type and rated voltage specified by the manufacturer shall be used.

3.2 Standard Atmospheric Conditions for Tests

3.2.1 Unless otherwise specified, all the tests shall be carried out under the following atmospheric conditions:

Temperature	27°C
Relative humidity	Not exceeding 80 percent
Atmospheric pressure	Between 860 and 1 060 mbar

NOTE — If the measurement is carried out at a temperature other than 27°C, the value shall be corrected to 27°C.

3.2.2 The instrument shall be protected from draughts and direct radiations.

3.3 Measurements

3.3.1 The measurements shall be made at two or more points on the scale as indicated under relevant measurement.

3.3.2 All measurements shall be made after the initial warm-up period specified by the manufacturer.

3.4 Accuracy of Test Instruments — The test instruments employed to carry out measurements in accordance with this standard shall have an accuracy of at least one order higher than that specified for the quantity under measurement.

3.5 Test Report — The test report shall clearly indicate the following:

a) Rated supply voltage, and

b) Atmospheric conditions under which tests are carried out.

4. VISUAL EXAMINATION

4.1 The *p*H meter shall be visually examined and inspected for conformity with the relevant provisions of IS : 2711-1966*.

5. TEST FOR ERROR OF INDICATION

5.0 The tests described under **5.1** and **5.2** shall be performed with the apparatus ready for use after warm-up time and within the ranges of influence quantities (temperature, humidity, etc), specified by the manufacturer in the literature provided with the *p*H meter.

5.1 Millivolt Scales — The calibration of *p*H meter scale shall be carried out using a dc potentiometer of high output impedance and have a scale interval in mV equal to one-tenth of the millivolt value of the scale interval of the *p*H scale under test, to apply a potential difference directly across the input terminals of the instrument. In all tests, measurements shall be made with both increasing and decreasing increments of applied potential differences to test hysteresis.

5.1.1 Before checking the mV scale (temperature compensator) shall be set in accordance with the manufacturer's directions.

NOTE — This is only necessary on certain *p*H meters where the temperature compensator remains in circuit on switching to the mV scales. Such instruments should not be used as millivolt meters without ascertaining that the temperature compensating device can be set to the value stated by the manufacturer with an accuracy consistent with that of the millivolt measurements.

5.1.2 The principal mV scale shall be tested at 100 mV intervals, and expanded scales at 25 or 50 mV intervals, using a potentiometer which has a scale interval at least one-fifth of that of the scale being tested.

NOTE — For example, with a 500 mV scale with scale interval of 10 mV, a potentiometer with settings of 2 mV is required.

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*Specification for direct reading *p*H meters (*second revision*).

If the set buffer control is effective on the mV scale, the control shall be used to set the zero initially. Both positive and negative regions of the mV scale shall be checked by reversing the input connections, with a double check of the scale zero.

5.2 *p*H Scales — Before checking the *p*H scales, the temperature compensator shall be set to 27°C (or to the calibration temperature stated by the manufacturer), the isopotential control (if fitted) to 7·0 (or where fixed isopotential values only are provided, to a value close to 7). With the input terminals shorted, the set buffer control shall be adjusted so that the indicator reads this isopotential value (or 7·0 on instruments without isopotential control). The manual temperature compensator shall be varied between its extreme settings, readjusting the set buffer control if necessary, until these variations produce no discernible change in indicator reading. The principal scale shall be calibrated at seven points between 0 and 14 by applying potential differences (appropriate to 27°C) from the potentiometer as shown in Table 1.

5.3 The overall instrument error shall be determined using the procedures described in **5.1** and **5.2**, with the additional feature that the potential differences from the potentiometer are applied through a 1 GΩ (± 10 percent) screened resistor to the glass electrode input.

NOTE — Under these conditions the test approximates closely to the normal usage of a *p*H meter.

6. METHODS OF TEST FOR ISOPOTENTIAL AND TEMPERATURE COMPENSATION

6.0 The manual and automatic temperature compensation (where provided) shall be checked by the following procedure.

6.1 Using the potentiometer, voltages shall be applied to the input terminals with either (a) different settings of the manual temperature control or (b) the temperature sensing device immersed for 30 min in baths at different temperatures (± 0·1°C) as given in Table 2. Observe the change in reading from the set value.

7. METHODS AND TESTS FOR INPUT CURRENT

7.1 Input Current at Zero Voltage — The set buffer control shall be adjusted with the input terminals shorted so that the indicator reads *p*H 7·000. A screened 10 G Ω (± 10 percent) resistor shall be connected across the glass and reference electrode inputs. The change in reading observed shall not exceed 1·5 *p*H which is equivalent to the value specified in **7.1** of IS : 2711-1966*.

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*Specification for direct reading *p*H meters (*second revision*).

TABLE 1 POTENTIAL DIFFERENCE FOR CALIBRATING *p*H SCALES

(*Clause* 5.2)

*p*H VALUE	dc VOLTAGE INPUT TO *p*H METER (mV)		
	At 0°C	At t_{max}°C	At 27°C
(1)	(2)	(3)	(4)
0	379	$379{\cdot}0 + \frac{t_{max}}{5} \times 7$	416·90
1	324·84	$324{\cdot}84 + \frac{t_{max}}{5} \times 6$	357·24
2	270·70	$270{\cdot}70 + \frac{t_{max}}{5} \times 5$	297·70
3	216·56	$216{\cdot}56 + \frac{t_{max}}{5} \times 4$	238·16
4	162·42	$162{\cdot}42 + \frac{t_{max}}{5} \times 3$	178·62
5	108·28	$108{\cdot}28 + \frac{t_{max}}{5} \times 2$	119·08
6	54·14	$54{\cdot}14 + \frac{t_{max}}{5} \times 1$	59·54
7	0	0	0
8	− 54·14	$-\left(54{\cdot}14 + \frac{t_{max}}{5} \times 1 \right)$	− 59·54
9	− 108·28	$-\left(108{\cdot}28 + \frac{max}{5} \times 2 \right)$	− 119·08
10	− 162·42	$-\left(162{\cdot}42 + \frac{t_{max}}{5} \times 3 \right)$	− 178·62
11	− 216·56	$-\left(216{\cdot}56 + \frac{t_{max}}{5} \times 4 \right)$	− 238·16
12	− 270·70	$-\left(270{\cdot}70 + \frac{t_{max}}{5} \times 5 \right)$	− 297·70
13	− 324·84	$-\left(324{\cdot}84 + \frac{t_{max}}{5} \times 6 \right)$	− 357·24
14	− 379·0	$-\left(379{\cdot}0 + \frac{t_{max}}{5} \times 7 \right)$	− 416·90

NOTE 1 — The millivolt values given in col 2 are derived from the following formula:

$$(54{\cdot}14 + 0{\cdot}2t) \; (pH_1 - pH_2)$$

where

t = temperature of measurement in °C,

pH_1 = *p*H value to which electrical zero is adjusted, and

pH_2 = *p*H value to be calibrated.

NOTE 2 — The values given in col 3 are derived from the following formula:

$$EpH = 379{\cdot}0 - [pH (54{\cdot}14 + 0{\cdot}2t) - 1{\cdot}4t] \text{ mV}$$

TABLE 2 VOLTAGES FOR CALIBRATING TEMPERATURE COMPENSATOR

(*Clause* 6.1)

(1)	(2)	(3)	(4)	(5)	(6)
Temperature setting or bath temperature (°C)	0	40	60	80	100
Applied voltage (mV)	±379·00	±435·00	±463·00	±491·00	±519·00

7.2 Input Current Change per Volt — A potential difference of 0·5 V shall be applied between the glass and reference electrode inputs.

NOTE — This can be done with a potentiometer but high accuracy is not required and a suitable source is the voltage drop across one of three 100 kΩ resistors connected in series across a 105 V dry battery. A representative circuit diagram for conducting test specified in this clause is shown in Fig. 1. The same circuit set-up can be used to test input current at zero voltage (**7.1**) keeping the potentiometer to the minimum.

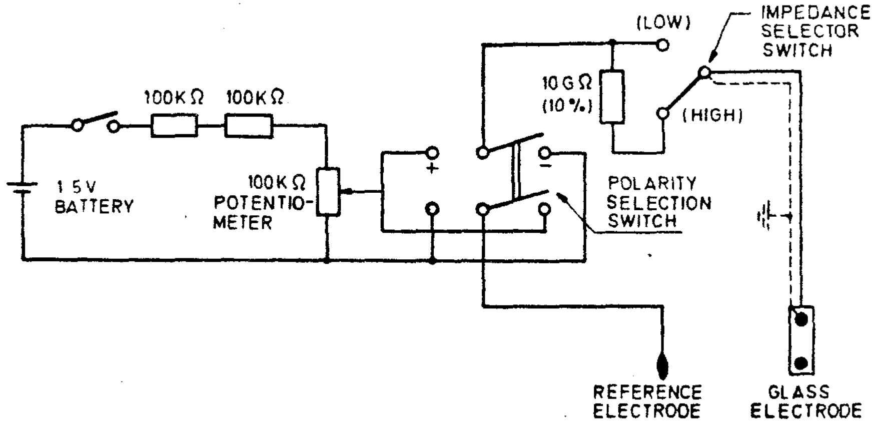

FIG. 1 TEST FOR INPUT CURRENT

NOTE 1 — The figure shall be suitably enclosed in a metal box and shall be suitably screened so as to shield it satisfactorily from vibrating electric field, electrostatic changes induced in the body of the operator, etc.

NOTE 2 — It shall be suitably earthed.

The set buffer control is adjusted so that the meter indicates a value on the scale. A screened resistor of 10 GΩ (± 10 percent) is connected in series with the voltage source and the change in reading observed. The polarity of the input voltage shall be reversed to repeat the observations. The difference between the greater of these two changes in reading and that in **7.1** shall be noted. It shall not exceed twenty times the overall accuracy for class A to D *p*H meters and hundred times the overall accuracy in case of class E *p*H meters.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Conversion*
Force	newton	N	1 N = 1 kg.1 m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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